Study on the Impact of Free Trade Zone Establishment on Enterprises' Green Total Factor Productivity

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Abstract. This study systematically investigates the impact of Free Trade Zone (FTZ) establishment on corporate green total factor productivity (GTFP). The analysis utilizes a sample of China's A-share listed companies from 2000 to 2024. The analysis utilizes a sample of China's A-share listed companies from 2000 to 2024. We treat the phased establishment of Free Trade Zone as a quasi-natural experiment and employ a multi-period difference-in-differences model for empirical analysis. The findings reveal that the establishment of Free Trade Zone significantly enhances firms' green total factor productivity. This study's conclusions offer empirical insights for deepening green institutional innovation, implementing differentiated environmental governance, and promoting coordinated regional green development within Free Trade Zone. It also provides evidence-based support for integrating high-level opening-up with the achievement of China's dual carbon goals.

Keywords: Free Trade Zone; Green Total Factor Productivity; Difference-in-Differences Model; Policy Effect.

1 Introduction

China’s high-quality economic transition faces salient challenges from traditional growth models, including tight resource constraints. The 20th CPC National Congress Report and the Third Plenary Session of the 20th CPC Central Committee have emphasized green development and ecological civilization institutions, making green total factor productivity (GTFP) a core indicator for firms’ green transformation [1].

As a key opening-up platform, China’s pilot free trade zones (FTZs) drive green development. The State Council’s 2025 document mandates FTZs to facilitate efficient allocation of green factors. Xiamen FTZ’s Xiangyu Comprehensive Bonded Zone, China’s first zero-carbon bonded area, achieved over 9,700 tons of annual CO_2 reduction and 10% higher productivity via photovoltaic storage and electrification, demonstrating FTZs’ role.Existing studies lack micro-mechanism analysis of FTZs’ impact on CGTFP. This paper uses firm-level panel data and a difference-in-differences (DID) model to identify the net effect and transmission channels. The marginal contributions

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of this study are mainly reflected in the following three aspects: expanding FTZ economic effect research, mitigating endogeneity via DID, and providing targeted references for optimizing FTZ green policies.

2 Literature Review

Domestic researches have analyzed the economic impacts of FTZs from multiple dimensions. Some studies adopt the DID approach to illustrate, from a dynamic perspective, that the growth-promoting effects of FTZs on regional economies present distinct temporal features. Other studies have adopted the PSM-DID method to dissect the intrinsic mechanisms that drive urban economic growth, including those related to capital, technology, and marketization. In terms of industrial structure, Feng Rui et al. (2020) adopted an incremental DID approach using interprovincial panel data, and found that FTZs significantly facilitate industrial structure upgrading through three key channels: innovation-driven mechanisms, optimized resource allocation, and industrial agglomeration [2]. In the context of macroeconomic growth, Zhang Jun et al. (2018) confirmed that the establishment of FTZs exerts a significantly positive impact on regional economic growth, presenting a U-shaped evolutionary trajectory [3]. At the micro-firm level, Fang Yunlong et al. (2021) conducted an analysis of ChiNext-listed companies and concluded that FTZs effectively boost both endogenous and exogenous innovation by easing financing constraints and enhancing firms' risk tolerance [4].

Foreign scholars have similarly explored the multifaceted impacts of FTZs. In the field of sustainable urban innovation-driven growth, Liu and Feng (2024) adopted multi-period DID, mediating effect models, and spatial DID models, and found that FTZ establishment significantly facilitates sustainable urban innovation-driven growth. This enabling effect is most prominent in eastern regions and large cities, acting through channels including talent agglomeration and foreign direct investment (FDI). Additionally, spatial spillover effects exist among geographically adjacent cities [5].

In terms of urban economic growth quality, Zhao and He (2022) adopted the DID method to verify that FTZs improve the quality of economic growth by leveraging institutional innovation to advance market-oriented reforms. Their findings show that the impacts are relatively stronger in coastal regions, the Guangdong-Hong Kong-Macao Greater Bay Area (GBA), and the second batch of FTZs [6]. Concerning regional economic resilience, Zhang and Tian (2025) used provincial panel data and a multi-period DID approach, and found that FTZs significantly boost regional economic resilience by about 3.46 percentage points. The development of green finance reinforces this effect, and the first batch of FTZs and coastal regions exhibit more prominent impacts [7]. With respect to green and high-quality development, Chang and Lai (2023) adopted the PSM-DID method and confirmed from the perspective of dual circulation that FTZs significantly facilitate regional green and high-quality development. Technological innovation and investment-driven mechanisms serve as key drivers, among the mediating effect of innovation is particularly prominent [8].

Overall, Existing research confirms FTZs positively impact economic growth, industrial upgrading, and innovation, noting effect heterogeneity. However, specialized

studies on their influence on firm-level GTFP remain limited. Against the backdrop of the digital economy and dual-carbon goals, this study employs a multi-period DID model with firm-level panel data to address this gap.

3 Policy Context, Theoretical Analysis, and Research Hypotheses

3.1 Policy Context

With "dual carbon" goals integrated into ecological civilization, promoting firms' green transformation and improving GTFP becomes key to high-quality development. As institutional innovation vanguards, Pilot FTZs have clarified green development orientations. Since 2013 (Shanghai FTZ's founding), green development has permeated FTZ reforms. The 2018 Hainan FTZ Plan advocated a green economy; 2022 saw national replication of FTZ measures like cross-border green tech transfer. The 2024 FTZ Green Development Action Plan built a multi-dimensional support framework. By late 2024, FTZs had implemented over 300 green reforms. CGTFP grew 12.7% annually, confirming institutional innovation's positive role in green transformation.

3.2 Theoretical Analysis and Hypothesis Research

The establishment of Free Trade Zones (FTZs) enhances corporate's Green Total Factor Productivity (CGTFP) primarily through three mechanisms: First, institutional openness promotes green upgrading of the industrial structure [9]. Policies such as the negative list management and relaxed foreign investment access attract high-tech, low-pollution enterprises while crowding out energy-intensive ones. Stricter environmental regulations and mechanisms like carbon emission trading internalize environmental costs, driving proactive green transformation and optimizing resource allocation. Second, FTZs facilitate green technology spillovers and knowledge diffusion. Introducing advanced international technologies and management experience generates significant imitation and learning effects. Cross-border R&D cooperation, talent mobility, and tariff preferences for green equipment lower innovation costs, encouraging R&D investment and improving technological efficiency. Third, FTZs intensify market competition and reform factor markets. Increased competition from international firms pressures local enterprises to enhance resource efficiency. Concurrent reforms in green finance and unified markets for energy and environmental rights direct capital and factors from polluting to green enterprises, correcting resource misallocation and boosting overall CGTFP.

H: The establishment of free trade zones enhances CGTFP.

4 Empirical Analysis

4.1 Empirical Model

To empirically examine the impact of FTZ establishment on CGTFP, this paper draws on relevant research to construct the following multi-period DID:

$$GTFP_{it} = \alpha + \beta FTZ_{it} + \gamma' Controls_{it} + Year_t + Firm_i + \varepsilon_{it} \quad (1)$$

Among these, green total factor productivity it denotes CGTFP i in year t; FTZ_{it} represents the policy shock variable for the establishment of FTZ. The coefficient β reflects the net impact of FTZ establishment on CGTFP of firms. $Controls_{it}$ represents a set of firm-level control variables, while $Year_t$ and $Firm_i$ denote the fixed effects for year and firm, respectively. ε_{it} is the random error term.

4.2 Variable Descriptions

1. Dependent Variable

CGTFP: Calculated using the global GML index based on the SBM directional distance function, then log-transformed to comprehensively reflect the firms' overall efficiency in economic growth, resource conservation, and environmental improvement.

2. Core Explanatory Variables

Free Trade Zone Establishment Policy (FTZ): Treat=1 if the firm is registered in the city where the FTZ is located, otherwise 0; Post=1 after policy implementation, 0 before implementation.

3. Control Variables

To more accurately assess the impact of free trade zone establishment on CGTFP and mitigate endogeneity bias caused by omitted variables, this study controls for the following firm-level characteristics in the model: To more accurately evaluate the impact of FTZ establishment on CGTFP and mitigate endogeneity bias arising from omitted variables, this study incorporates the following firm-level characteristic variables into the model as controls:(1) Firm size (Size), represented by the natural logarithm of total assets at the end of the period. (2) Profitability (ROA), measured as the ratio of net profit to total assets. (3) Cash Flow Level (Cashflow), expressed as the ratio of net cash flow from operating activities to total assets. (4) Fixed Asset Ratio (FIXED), measured as the ratio of net fixed assets to total assets. (5) Growth, using revenue growth rate as a proxy variable. (6) Shareholder Balance (Balance1), measured as the ratio of the combined shareholding of the second to tenth largest shareholders to the shareholding of the largest shareholder. (7) Management Expense Ratio (Mfee), expressed as the ratio of management expenses to operating revenue.

4.3 Data Sources

Treating FTZ establishment as a quasi-natural experiment, this study identifies its causal impact on firms' GTFP. Policy variables are constructed using FTZ approval

dates and coverage areas from State Council and Ministry of Commerce documents. The sample includes Chinese A-share listed companies (2000–2024) matched with city-level data. Firms' GTFP is measured via the SBM-DEA directional distance function-based GML index, using data from CNRDS and China Industrial Enterprise Database. Control variables are from CSMAR and statistical yearbooks; missing values are supplemented with annual reports or smoothed interpolation.

5 Benchmark Results Analysis

Table 1. Benchmark Regression Results

	(1)	(2)	(3)
VARIABLES	GTFP	GTFP	GTFP
did	0.0011***	0.0012***	0.0014***
	(3.378)	(3.422)	(3.882)
Control vars	controlled	controlled	controlled
Constant	1.0233***	1.0050***	0.9984***
	(5,597.711)	(178.997)	(161.417)
Observations	43,959	41,295	37,312
R-squared	0.975	0.975	0.975
firm FE	Yes	Yes	Yes
year FE	Yes	Yes	Yes

Note: Standard errors in parentheses are robust. * indicates $p < 0.1$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.

The benchmark estimation results on the impact of free trade zone establishment on CGTFP are reported in Table 1. As exhibited in all three models, the coefficient of the core explanatory variable is statistically significant at the 1% level which indicates that FTZ establishment significantly promotes the improvement of CGTFP, thereby validating the research hypothesis that FTZ has a positive impact on firms' green production efficiency.

6 Conclusions and Policy Recommendations

This study takes the phased establishment of FTZs as a quasi-natural experiment, and adopts a multi-period DID model to systematically assess the impact of FTZ establishment on CGTFP. Results show that FTZ establishment significantly boosts CGTFP, primarily through three mechanisms: environmental regulation-driven upgrades, technology spillovers, and optimized resource allocation. This study holds significant policy implications: First, promote and replicate the successful experience accumulated in FTZ development, further advance and refine green institutional innovations, and upgrade supporting infrastructure. Going forward, efforts should focus on the orderly ex-

pansion of FTZ pilots, while advancing the in-depth integration of green and low-carbon policies with other FTZ-related initiatives. Cities boasting solid environmental foundations should strengthen green incentive and guidance systems, while those with weaker foundations must speed up remedying gaps in green infrastructure, thereby enabling the broader application of the "FTZ + green transition" model. Second, it is necessary to smooth the channels through which FTZs boost CGTFP and fully unlock policy dividends. Specific measures are as follows: First, optimize factor allocation: through negative list management and other approaches, guide various green factors to gather in FTZs. Second, amplify technology spillover effects: support enterprises in carrying out international green technology cooperation via the FTZ platform. Third, give full play to the impetus of environmental regulations, upgrade green market mechanisms and the environmental standards system, thereby arousing firms' intrinsic motivation for green transformation.

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